Materials Engineering Branch

TIP*

No. 093 Temperature Cycling of Electronics Safely

Author(s): Diane Kolos Contact: (301) 286-6882

A recent experience involving several printed circuit boards suggests the need to emphasize some basic rules for temperature cycling electronic assemblies. The boards in question included one flight and nine flight spares all of which were cycled at atmospheric pressure from elevated temperature to cryogenic temperatures using carbon dioxide as the test chamber refrigerant.

These boards were not conformally coated prior to the test and were electrically active during the cycling. As a result, water condensed and tin dendrites (crystals) formed between surface traces on the board and at the glass-to-metal seal of several dual inline packages (DIPs) populating the assembly. The dendrites on the board surface formed conductive paths between the traces, of isolated circuits, causing the boards to fail electrical testing.

The formation of such dendrites is termed electro-migration and is a commonly recognized phenomenon in the electronics industry. The dendrites form when two adjacent current carrying conductors are spanned with a continuous moisture film (even distilled water). The result is an electroplating-like process that deposits a conductive path between the conductors creating a short in the circuitry.

The ideal method would be to cycle electronic assemblies in a vacuum chamber that would, if properly done, preclude the formation of a condensate entirely. However, if this is not possible, some basic rules apply when temperature cycling powered electronic circuitry in the presence of moisture and current.

The assemblies should never be cycled to temperatures capable of condensing moisture on the circuitry without the protection of a continuous, defect-free conformal coating. Carbon dioxide is no longer approved as a refrigerant to cold temperature cycle electronic assemblies because the moisture condensed by this compound forms carbonic acid, which has been previously identified as a cause of component lead corrosion. Liquid nitrogen is now the commonly used refrigerant for this type of application because it does not condense a corrosive liquid during the cooling cycle. When cycling with closed loop refrigeration systems, use a continuous purge of dry nitrogen in the chamber to prevent moisture accumulation.

Finally, in all tests involving a hot and a cold cycle make sure that the last cycle is hot (above room temperature) so that opening of the chamber does not result in condensation on the parts being tested.

Separately, neither the use of liquid nitrogen or conformal coating provides a solution. A conformal coating will inhibit dendrite formation in the presence of moisture, but, if carbon dioxide is used the condensate from the cycling will be corrosive and any discontinuity in the coating could result in corrosion of the component leads. Conversely, if liquid nitrogen is used without the conformal coating the condensate which forms will not be corrosive, but it still will be capable of forming dendrites on the board and components. Both requirements must be met to safely temperature cycle powered electrical assemblies.

References

Jennings, Charles W., "Filament Formation on Printed Wiring Boards,"
IPC Technical Review, February 1976, pp 25-32